Methods for innovation projects risk evaluation

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METHODS FOR INNOVATION PROJECTS RISK EVALUATION

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Abstract: Starting an innovation project assumes to state some competitive objectives referring to the allocated budget, time limit for project's ending and also to the quality and performance parameters of the new obtained product.
Referring to the innovation project development, the risk of unfulfilling the stated competitive objectives referrers to the exceeding the project's budget and terms, and also to unfitting in the quality and performance parameters established in the innovation project planning stage.
The large diversity of risk sources can be expressed by the possibility of appearance of some unexpected variations of the cost, time and quality of the new products. The innovation projects risk is settled by the variations of the cost, time and quality objectives effective values comparing to the planned values. Those variations are determined by purely random factors.
The innovation projects characterized by uniform variations of the cost, time and quality objectives effective values around the mean are considered to be under statistic control. Those projects' risk may be quantified and the risk impact over the project can be limited. The innovation projects characterized by fluctuant variations of the cost, time and quality objectives effective values around the mean are considered to be out of statistic control.
The aim of this paper is to present two categories of statistic methods for innovation projects risk quantifying. The first statistic methods that quantify the risk of unfitting the quantitative objectives referrers to the time risk, cost risk and the risk of unfitting established performance parameters. The second category of methods represents statistic methods that quantify the risk of unfitting the qualitative objectives of the projects – the risk of appearance major quality deficiencies.

1. Introduction

Developing an innovation project at the enterprise level means to assume some risks and uncertainties. The risk and uncertainty are higher according with the newness degree of the project. The uncertainty may be considered the distance between the necessary information and the existent information about the new activity. Usually, only the radical innovation projects referring to an absolute new activity or product are subject of uncertainty. The other innovation projects are subject of risk. In this context, the risk of an innovation project can be defined to be "the measure of probability and consequences to not reach the project's objectives" and always bear an associated cost [2]. The risk of unfulfilling the competitive objectives of the innovation project means to exceed the project's budget and terms or to unfit in the quality and performance parameters established in the innovation project planning stage.

The risk of exceeding the time terms of the innovation project, called “time risk”, is significantly influenced by the duration of the project. A project has a high time risk when it’s duration in time is very long or if the project consists in a number of sub-projects with critical time terms. In developing of the very long projects can appear dead times given by the necessity to reorganize the activity according with the environment changes. Those dead times can determine discontinuities in project’s fulfilling. The dimension of the time risk for a project’s activity is larger according with the shortness of its duration.

The risk of exceeding the budget of the innovation project, called “cost risk”, appears because the defections in developing the project. Most of times, the cost risk is determined by the penalties due to the exceeding of planned durations.

The risk to unfit in the quality and performance project’s parameters, called “quality risk”, refers to the possibility that the product do not satisfy the consumer’s needs. The quality criteria can be expressed both quantitative and qualitative, thus:

- The fitting in the technical inquiries – express the measure in which the new product satisfy the expected technical performances;
- The value – express the measure in which the new product can contribute to accomplish the planned financial and commercial objectives (market share, turnover or profit) in the competitive price conditions;
- The utility – express the measure in which the new product reaches it’s utility objective;
- The services attached to product – refers to guarantee or post-guarantee services;
- The psychological impact – refers to product’s image and to its esthetical features.

The risk of an innovation project activity can be determined based on the partial risks afferent to the activity – the time risk, the cost risk and the quality risk. It is assumed that the risk of activity is given by the largest variation of the cost, time and quality objectives effective values comparing to the planned values. The time risk can be determined by composing the time risks for each project’s activity. Similarly, can be quantified the cost risk and the quality risk of the innovation project.

The global risk of the innovation project can be found out composing the partial risks, referring to time, cost and quality, for all the project’s activities. Thus, the dimension of the global risk of the innovation project is given by the largest variation of the cost, time and quality objectives effective values comparing to the planned values, considering all the project’s activities. Usually, the innovation projects are developing on long time periods and the risks implied is due to the small possibilities to anticipating all the environment changes that can appear on the period of project implementation.

The estimations referring to developing way of the innovation projects in the respects of cost, time terms, quality of new products and the revenues associated are based on some inherent inexactitudes, predictable and calculable. The effective values of costs, time terms, quality of new products can fluctuate from the estimated values due to the incomplete information about the future and to the deficiencies in the project coordination and control.

2. Possibilities of measuring the innovation project risk

The great diversity of risk sources for the innovation projects can be expressed by the possibility of appearing unpredicted variations of the cost, time terms or quality objectives. The causes of these variations can be separated in two important categories: quantifiable variations and random variations. The quantifiable causes of the variations refer to the factors that have significant influence on the developing of the innovation project and can be identified and eliminated.

The causes of the random variations have purely random character and refer to unidentifiable sources of risk that cannot be avoided in the developing of the innovation project. In the conditions of fast growing of the technological progress, there are more frequent cases when the unfitting in the planned values of cost, time terms or product quality are due not to a bad planning or bad management but to difficulties to anticipate changes in the technological part of the project. Thus situations are frequently seen in the high technologies domain.

The risk of an innovation project is given by the variations of the effective values of the cost, time terms and quality objectives from the planned values determined by the purely random factors. From statistic point of view, the risk of the innovation project can be calculated with the standard deviation, denoted σ. The main objectives of the project's managers are to identify the uncertainty sources and to take the proper actions to limit the uncertainty and to change it in risk that can be monitored.

The risk management methods allow both the risk identification and the estimation of the impact of some events but without the possibility to establish generally valuable rules. The dimensioning of the innovation project's risk is based on the information's accuracy and promptitude referring to the project, on the generally known methods used to quantify the risk and, not in the last, on the experience of the managers given by the developing of some previous projects. Thus, the manager's role is to eliminate the quantifiable variations and to identify the causes that determine random variations and to minimize the impact of these variations on the new product.

Ideally, it is considered that the variation of the effective values of cost, time terms and quality from the planned values dues only to random factors. That means that the effective results average is equal with the estimated average and the distribution of the observed values is symmetric around the mean value. But in the real activity the variation of the effective values of cost, time terms and quality from the planned values dues both to random factors and to quantifiable factors. That situation determines an asymmetric distribution, to left or to right, of the observed valued around the mean value.

The innovation projects with a stable variation in time of the effective values of cost, time terms and quality around the mean are considered to be under statistic control. The risk of these kinds of projects can be quantified and its impact on project can be limited. The projects with fluctuant variation in time of the effective values of cost, time terms and quality around the mean are influenced both by the random factors and quantifiable factors and cannot be put under statistic control. The distribution of the effective values of cost, time terms and quality referring to an innovation project are characterized by the mean, by the variation around the mean and by the shape of distribution.

1. The mean of the observed values ($\overline{x}$) is calculated as ratio between the sum of the observed values (x_i) and the number of observations (n), after the relation:

$$\overline{x} = \frac{\sum_{i=1}^{n} x_i}{n} \tag{1}$$

2. The variation of the observed values around the mean is quantified with three statistic parameters:
   - The absolute amplitude of variation (A) calculated as difference between the maximum observed value (x_{max}) and minimum observed value (x_{min}), thus:

$$A = x_{max} - x_{min} \tag{2}$$

   - The variance (σ^2) obtained with the relation:

$$\sigma^2 = \frac{\sum_{i=1}^{n} (x_i - \overline{x})^2}{n} \tag{3}$$

   - The standard deviation (σ) determined after relation:

$$\sigma = \sqrt{\frac{\sum_{i=1}^{n} (x_i - \overline{x})^2}{n}} \tag{4}$$

3. The shape of the observed values distribution can be given both by a symmetric curve around the mean value and by an asymmetric curve, bended to the left or right. If the variation of the observed values from the planned values is due only to random factors, then the observed values distribution is symmetric around the mean value.

The statistic control of the innovation project is based on the processes statistic control methods [1]. These methods consist in a monitoring methodology used to see the ways to accomplish the objectives and to eliminate the quantifiable causes of variations. In that methodology can be distinguished methods for measuring the risk of unfitting the quantitative objectives (cost, time terms and some performance features) and the risk of unfitting the qualitative objectives.

3. Statistic methods for measuring the risk associated with quantitative objectives

That methodology assumes to quantify the time risk, the cost risk and the risk of unfitting the planned performance indicators based on statistic control methods. The methods used are:

- The statistic control method for the mean value of the project's objectives (based on statistic tests Laplace and Student);
- The statistic control method for the variance around the mean values of the project's objectives (based on statistic test χ^2);

The statistic control method for the mean value of the project's objectives is used when the variability of the effective values of the project is given only by random factors and allows the monitoring of the mean values of the project's objectives [4]. This method can be applied in two variants.

The first variant can be used when the sample dimension is larger than 30 values and the variance of the process is known by previous experience. In that case, the confidence interval for the average of the mean value of the project's objectives is determined with z test based on Gauss-Laplace distribution [5], after the relation:

$$P\left(\bar{x} - z \cdot \frac{\sigma}{\sqrt{n}} \leq m \leq \bar{x} + z \cdot \frac{\sigma}{\sqrt{n}} \right) = 1 - \alpha \qquad (5)$$

Where: P is the probability for the mean value of the project's objectives to be into the confidence interval, also known as confidence level of the test;
$\bar{x}$ is the mean of the observed values, calculated with relation 1;
z is a critical value from the Gauss-Laplace distribution tables;
σ is the standard deviation of the process, known from previous experience;

n is the sample dimension (larger than 30 values);
m is the mean value of the project's objectives;
α is the probability for the mean value of the project's objectives to be out of the confidence interval, also known as significance level of the test;

While the mean value of the project's objectives *m* fits in the confidence interval, the variations of the effective mean values from the planned mean values are under statistic control. That means that the variations of the effective values from the planned values are purely random and they not have a significant influence. In these conditions, the innovation project is developing in planned circumstances and can go on. While mean values for some of the projects objectives are not fitting in the confidence interval the variations of the effective values from the planned values are due to quantifiable factors with significant influence. Those factors have to be identified and removed for the good developing of the innovation project. This variant of statistic method can be used only when the project manager has previous experience in the domain and the sample data is very large.

The second variant can be used when the sample dimension is smaller than 30 values and the variance of the process is not known. In this case, the confidence interval for the mean value of the project's objectives is determined with *t* test based on Student distribution [5], after the relation:

$$P\left(\bar{x} - t \cdot \frac{s}{\sqrt{n}} \le m \le \bar{x} + t \cdot \frac{s}{\sqrt{n}} \right) = 1 - \alpha \qquad (6)$$

Where: t is a critical value from the Student distribution tables with $v = n - 1$ degrees of freedom;
s is the standard deviation of observed values from the sample;

The meanings of the confidence interval with Student test are the same with previous variant. The difference consists in the fact that this second variant can be used without previous experience and having a smaller sample date at disposition. The practical results of the first variant are better than the second variant, because the confidence interval determined after relation 5 is more accurate than the confidence interval determined after relation 6. Unfortunately, in a great number of cases, the managers has no previous innovation experience and the available sample data is small, so they are forced to use the second variant with lower accuracy.

The statistic control methods for the variance around the mean values of the project's objectives come to complete the statistical analysis because it is not sufficient to have the mean of the objectives under statistic control. For a good developing of the innovation process it is needed to have both the mean and the variance of the project's objectives under statistic control. The confidence interval for the variance around the mean values of the project's objectives is determined with χ^2 test based on χ^2distribution [3], after the relation:

$$P\left(\frac{(n-1)\cdot s^2}{\chi^2_{\frac{\alpha}{2}}} \le \sigma^2 \le \frac{(n-1)\cdot s^2}{\chi^2_{1-\frac{\alpha}{2}}}\right) = 1-\alpha \qquad (7)$$

Where: s^2 is the standard deviation of observed values from the sample;
σ^2 is the variance of the project's objectives;
$\chi^2_{\frac{\alpha}{2}}$ and $\chi^2_{1-\frac{\alpha}{2}}$ are critical values from the χ^2 distribution tables

When the variance of the project's objectives σ^2 fits in the confidence interval, the variations of the effective values from the planned values are under statistic control. When variance for some of the projects objectives are not fitting in the confidence interval the variations of the effective values from the planned values are due to quantifiable factors with significant influence. The statistic analysis has to be conducted on the idea that the mean and the variance of the innovation process must be situated into the confidence intervals on the entire period of the project. If the mean or variance come out from the confidence interval the project manager must intervenes and make the necessary corrections.

4. Statistic methods for measuring the risk associated with qualitative objectives

The quality features of a new product can be evaluated with several methods and the result consist in admission or rejection to produce that product. A very efficient method is the monitoring of the percentage of defect products generated by the innovation project. This method allows measuring the risk of appearance of quality deficiencies. The method starts with selecting a random sample of products and evaluating the quality features of each product from the sample. Then, the products with quality defects are put separately and is calculated the percentage of the defect products in the total amount of the sample, after the relation:

$$P_d = \frac{n_d}{N} \qquad (8)$$

Where: P_d is the percentage of the defect products;
n_d is the number of defect products from the sample;
N is the dimension of the sample.

The method implies to classify the products in two categories: products with quality deficiencies and products which accomplish the quality standards. A product can fit only into one from these two categories, there is no other alternative. That means a binomial distribution of the observations. For large samples the normal distribution can give an accurate approximation of the observed values distribution. The monitoring of the percentage of defect products generated by the innovation project assumes to cover the following stages [1]:

1. Calculating the standard deviation of percentages of products with quality defects (σ_p) after the relation:

$$\sigma_p = \sqrt{\frac{\overline{p}(1-\overline{p})}{N}} \tag{9}$$

In which: $\overline{p}$ is the mean of the percentages of products with quality defects. In some cases, that mean can be replaced with the established target value of the percentage of products with quality defects for the innovation project.

2. Obtaining the upper limit for the effective values of the percentages of products with quality defects (UL_p) after the relation:

$$UL_p = \overline{p} + Z \cdot \sigma_p \tag{10}$$

Where: Z is the normal standardized deviation.

3. Obtaining the lower limit for the effective values of the percentages of products with quality defects (LL_p) after the relation:

$$LL_p = \overline{p} - Z \cdot \sigma_p \tag{11}$$

The upper and lower limits delimitate the confidence interval for the percentage of products with quality defects.

4. Periodically is selected a random sample of N products which will be evaluated to discover the quality deficiencies. Then, the effective percentage of products with quality defects from the sample will be determined. If the value obtained is not situated into the confidence interval delimited by upper and lower limits then the variation of the percentage of products with quality defects is given by quantifiable factors with significant impact. The process has to be analyzed and the quantifiable variation factors must be identified and

eliminated. If the value of the effective percentage of products with quality defects from the sample fits into the confidence interval, then the variation of the percentage of products with quality defects is given by random factors and the product is under statistic control.

5. Conclusion

The main objective of an innovation project manager is to maintain the innovation projects under statistic control because the risk of those projects can be quantified and its impact on project can be limited. The innovation project manager's role is to eliminate the quantifiable variations of effective values relative to planned values of cost, time terms and quality, to identify the causes that give random variations and to minimize the impact of these variations.

The projects with fluctuant variation around the mean of the effective values of cost, time terms and quality are not desirable because can generate distortions and can have unpredictable impact upon the new product. The innovation projects characterized by fluctuant variations of the cost, time and quality objectives effective values around the mean are considered to be out of statistic control and managers have to intervene for adjusting the project's parameters.

The statistic methods presented consist in a way of control used to identify the path to accomplish the objectives and to eliminate the quantifiable causes of variations. Managers can use statistic methods that quantify the risk of unfitting the quantitative objectives referring to the time risk, cost risk and the risk of unfitting established performance parameters and, also, statistic methods that quantify the risk of unfitting the qualitative objectives of the projects.

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